ELECTRONIC PACKAGE HAVING ACTIVE MEANS TO MAINTAIN ITS OPERATING TEMPERATURE CONSTANT

BACKGROUND OF THE INVENTION

1. Field of the Invention

The present invention relates to a semiconductor package cooling and more particularly to an apparatus and method for providing a variable rate of cooling locally in the package to maintain a constant operating temperature.

2. Description of the Prior Art

Most high power CMOS logic chips planned for future computers are expected to operate under one or more power management schemes. In these schemes, portions of the on-chip circuits can be turned off when they are not needed or the clock rate can be reduced when the processing speed is not required. The overall power dissipation of the chip is thereby decreased and these reductions can occur in a cyclic fashion with time periods on the order of hundreds of seconds. Since the cooling rate of the packages is generally constant, this means that the chip temperature can fluctuate corresponding to the chip power cycles. The temperature excursions of this kind will generate thermal fatigue damage in the packaging materials especially the printed circuit board interconnections.

Semiconductor package cooling systems are well known in the art. Variable speed fans controlled by a temperature sensor are disclosed in U.S. Pat. Nos. 5,121,291, 5,102,040, 4,817,865 and 4,664,542, as well as in research disclosures RD 31094 dated 2/90 and RID 26947 dated 9/86, and IBM Technical Disclosure Bulletins Vol. 32 No. 10A dated 3/90 and Vol. 26 No. 4 dated 9/83.

U.S. Pat. No. 5,121,291 discloses a cooling system with exhaust and intake fans, the speeds of which are controlled by the temperatures in the system. U.S. Pat. No. 5,102,040 discloses the use of the inlet air temperature and the temperature difference of the inlet and outlet air as the control parameters for the cooling fans. U.S. Pat. No. 4,817,865 discloses a cooling scheme of a modular system in which each modular compartment has a temperature sensor and the temperature reading is used to control the speed of a cooling fan. U.S. Pat. No. 4,664,542 discloses a control circuit design for a print head in which the temperature of the printing head is sensed and used to control the printing and fan speeds.

RD 31094 discloses a scheme to change the fan speed by detecting the presence of human operators around a system. RD 26947 discloses a memory-chip cooling scheme in which the speed of a fan is changed according to the electric current intake of the memory chips. IBM TDB Vol. 32 No. 10A discloses a fan design that has an air temperature sensor integrated within, such that the fan speed is adjusted to the surrounding air temperature.

IBM TDB Vol. 26 No. 4 discloses a speed control circuit for a DC fan using several temperature sensors. The highest temperature reading is used to control the fan supply voltage and hence the fan speed.

Attempts to provide local cooling within semiconductor packages have also been made.

U.S. Pat. No. 4,931,904 discloses a scheme to enhance local cooling to a board by adding fans or ducts to an adjacent board. The fan speed can be adjusted accordingly. U.S. Pat. No. 4,449,164 discloses a cooling scheme using

longitudinal fins of a heat sink on a module and a tube surrounding the fins for guiding the air flow. SU 1476629 discloses an electronic unit having heat sinks placed between the PCB and heat elements, and baffles at the main coolant path to lead the coolant to the heat sinks. JA 0076299 discloses an electronic cabinet for housing a plurality of PCB's mounted vertically with thermosensitive shutters on the exhaust side of the cabinet. The shutters are normally closed if no PCB's are plugged in.

There is a need for a local active cooling system having a variable control system for use in the power management environment of excessive on-off cycles to maintain semiconductor chips at an appropriate constant temperature.

SUMMARY OF THE INVENTION

The present invention is directed to a package structure for maintaining a semiconductor chip at approximately a constant temperature in an environment where the power consumption of the chip is variable which comprises means for monitoring the present temperature of the chip and means for varying air flow over a heat sink in thermal contact with the chip. A control means connects the means for monitoring the present temperature of the chip to the means for varying the air flow such that the air flow is increased when the chip temperature increases and the air flow decreases as the chip temperature decreases. In accordance with the present invention, the means for varying the air flow includes a variable speed fan or alternatively a variable direction baffle and a constant speed fan. The means for monitoring the present temperature of chip may include temperature sensors on or near the chip or means for measuring the current supply to the chip and a control circuit for converting the current reading to a temperature based on a predetermined relationship.

In another embodiment of the present invention, the parameter used to control the variance of the air flow over the heat sink is the temperature difference between the semiconductor chip module and the printed circuit board on which the module is mounted. The temperature sensors are attached to the module and the printed circuit board and a control means monitors the temperature difference and regulates the air flow to maintain the difference to a preset value. In addition, a separate temperature sensor may also be in thermal contact with the chip or actually embedded in the chip so that the control means regulates the air flow over the heat sink in response to the chip temperature as well as the temperature difference between the module and the printed circuit board.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 is a schematic cross-sectional view of a semiconductor package having the local chip module cooling apparatus of the present invention.

FIG. 2 is a schematic block diagram of the control circuit for controlling a variable speed fan in accordance with the present invention.

FIG. 3 is a schematic cross-sectional view of a semiconductor package having a variable direction baffle in accordance with the present invention.

DETAILED DESCRIPTION OF THE INVENTION

Referring now to the drawings, FIG. 1 is a schematic layout of a single chip module. A single chip module 12 is soldered to a printed circuit board 11 using solder balls 15.